RESEARCH DEPARTMENT

Self-generated vision-on-sound interference in 625-line television receivers using intercarrier sound

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SELF-GENERATED VISION-ON-SOUND INTERFERENCE IN 625-LINE TELEVISION RECEIVERS USING INTERCARRIER SOUND

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SUMMARY

This report describes a mechanism by which non-linear distortion of the video-frequency signal in television receivers using the intercarrier sound technique can produce interference in the sound channel. The design features that affect the susceptibility to this form of interference are discussed and, as an example, the results of objective measurements on two domestic television receivers are given.

1. INTRODUCTION

With the intercarrier sound arrangement used in standard 405/625-line receivers currently in production in the U.K., the 625-line vision and f.m. sound signals pass through a common i.f. amplifier to the vision detector. At the output of this detector there appears, with the demodulated picture signal, the so-called intercarrier sound signal which has a frequency equal to the difference between the frequencies of the vision and sound carriers, i.e. a 6 Mc/s signal, frequency modulated with the sound information. This intercarrier signal is applied to an amplifier, limiter and discriminator operating at 6 Mc/s. In order to reduce the effect of intermodulation between the sound and chrominance carriers when receiving a colour transmission, which could produce an undesirable beat pattern at approximately 1·57 Mc/s, it is necessary to attenuate the sound signal in the i.f. amplifier by at least 30 dB relative to the vision carrier.[1] The video signal at the detector is thus considerably greater in amplitude than the intercarrier sound signal. If the video signal contains components of sufficient amplitude at frequencies which are integral sub-multiples of 6 Mc/s, non-linear distortion in the receiver may produce harmonics at 6 Mc/s which are comparable in amplitude with the intercarrier sound signal. These harmonics can produce audible interference in the sound output of the receiver.

2. NON-LINEAR DISTORTION OF THE VIDEO WAVEFORM

One way in which harmonics of the video modulation frequency are generated within the receiver is by the 'quadrature distortion' which occurs when a signal consisting of a carrier plus a single sideband is rectified in an envelope detector.

With this type of distortion only the second harmonic is likely to be sufficiently large to cause trouble and its amplitude can be calculated for an ideal receiver.

The following assumptions will be made:

(a) The response of the receiver up to the video detector is such that the vision carrier is attenuated by 6 dB relative to the upper sideband produced by video modulation at a frequency of 3 Mc/s.

(b) The vision detector and preceding amplifier stages are linear.

(c) The characteristics of the transmitted signal are those adopted for 625-line television broadcasting in the U.K.[2]

In these conditions, with video modulation consisting of a 3 Mc/s sinusoidal waveform having a peak excursion from black level to peak white level, it can be shown, using Colebrook's analysis,[3] that the ratio

$$R_H = \frac{\text{r.m.s. value of second harmonic}}{\text{peak-to-peak amplitude of composite video waveform}}$$

will have a value of -30 dB.

In order to reduce the sound-to-chrominance beat pattern to an acceptable level when receiving colour transmissions it has been recommended[1] that the sound carrier should be attenuated by at least 36 dB, relative to the mid-band video sideband response, in the receiver. Taking into account the 7 dB vision-to-sound carrier ratio of the transmission, this will produce an intercarrier component at the output of the video detector such that the ratio

$$R_I = \frac{\text{r.m.s. value of intercarrier component}}{\text{peak-to-peak amplitude of composite video waveform}}$$

has a value of -38 dB.

In the conditions postulated, the second harmonic of the video modulation is at the same frequency as the intercarrier sound signal and 8 dB greater in amplitude, and is, therefore, certain to give rise to audible interference. However, the case calculated above represents continuous full modulation at 3 Mc/s; in practice any 3 Mc/s detail in the picture will normally only occur over limited parts of the picture area and will consequently produce pulses of 3 Mc/s repeated at the line and field scanning frequencies. In such cases the second harmonic energy will be spread over a bandwidth determined by the duration of the pulses, and the peak value of the interference reaching the sound channel discriminator will depend on the bandwidth of the intercarrier-frequency circuits.

As far as quadrature distortion is concerned only the second harmonic term, i.e. that arising from video modulation at 3 Mc/s, is likely to cause sound channel interference; higher order harmonics of lower video modulation frequencies will generally be too small to be troublesome. In some receivers, however, the input to

the intercarrier sound channel is taken not from the video detector but from the output of the video amplifier. In such cases non-linear distortion in the video amplifier can produce harmonic components within the bandwidth of the sound channel and the higher order harmonics may be significant.

3. EXPERIMENTAL INVESTIGATION

It appears from the foregoing discussion that several aspects of the receiver design will affect the susceptibility to this form of sound interference.

(a) The overall response/frequency characteristic of the signal-frequency and intermediate-frequency circuits, which will determine the relative amplitudes of the vision carrier, sound carrier and 3 Mc/s upper sideband at the input to the vision detector.

(b) The bandwidth of the intercarrier sound circuits.

(c) The response of the intercarrier sound channel to interference, one important facet of which is the efficiency of a.m. suppression.

(d) The linearity of the video amplifier in those receivers in which this stage is common to both vision and sound channels.

To assess the importance of these effects in a practical case, measurements were made on two domestic switchable 405/625-line television receivers.

In receiver A the intercarrier sound signal is taken from the output of the video amplifier. Fig. 1 shows the effect of non-linear distortion arising in

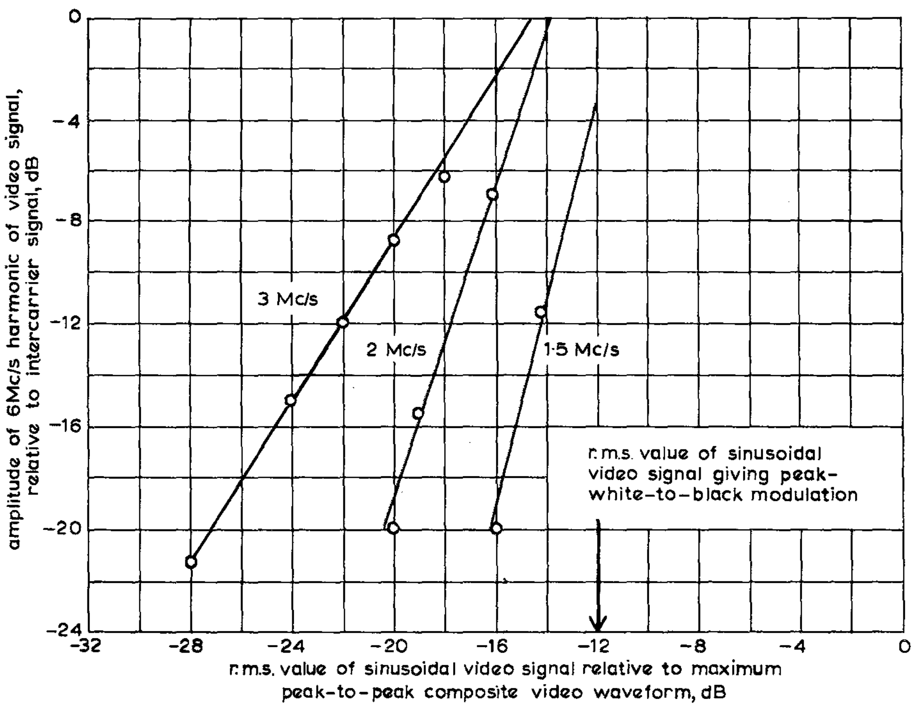

Fig. 1 - Non-linear distortion in video amplifier, receiver A

this stage; the normalized levels of video and intercarrier signals in this test were those obtained with the contrast control of the receiver set to give a reasonable picture in a normally lit room. If the setting of the contrast control were advanced, the signal level at the input to the video amplifier would be raised and the 6 Mc/s harmonics of any sub-multiple frequencies present in the video signal would increase in amplitude relative to the intercarrier signal.

Fig. 2 shows the i.f. amplifier response/frequency characteristic and Fig. 3 the response/frequency characteristic of the intercarrier sound 6 Mc/s amplifier, both for receiver A.

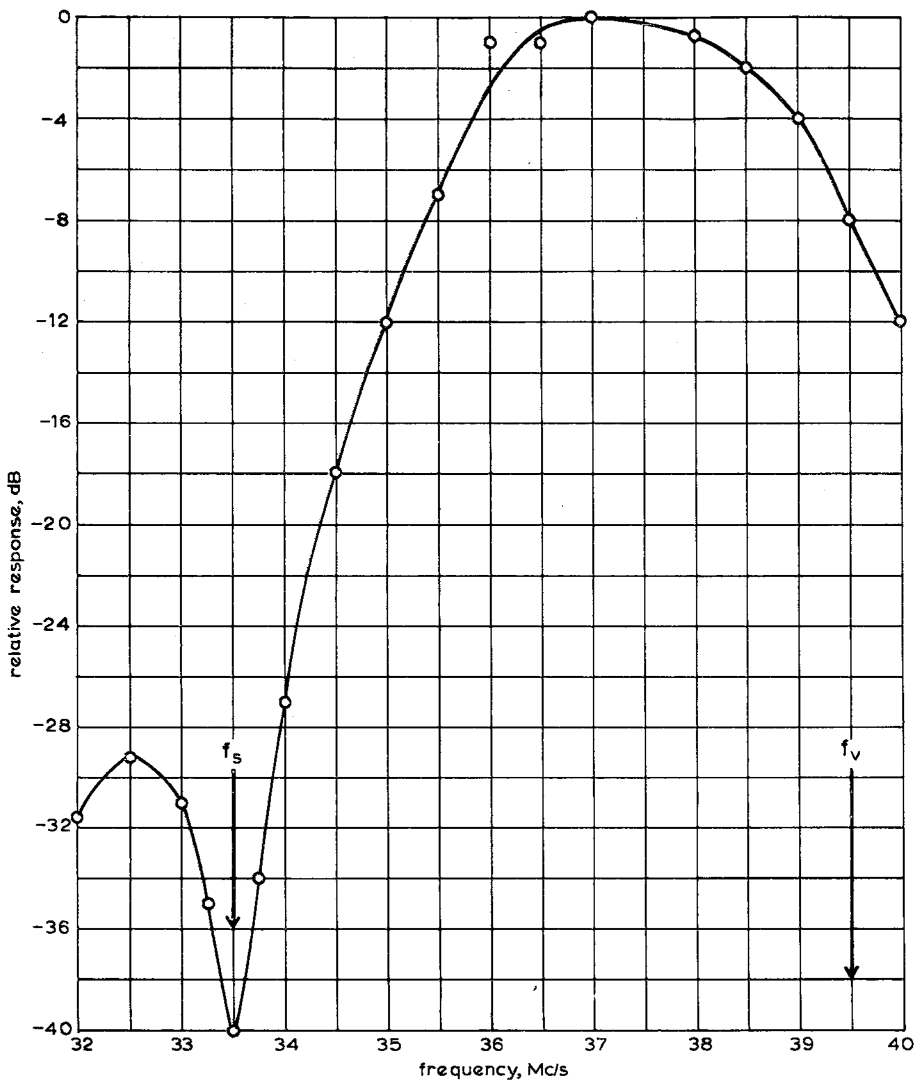

Fig. 2 - I.F. amplifier response, receiver A

Figs. 4 and 5 show the response/frequency characteristics of the i.f. amplifier and intercarrier 6 Mc/s amplifier, respectively, for receiver B. In this receiver the intercarrier signal is taken directly from the video detector; there is, therefore, no common video amplifier stage in which appreciable harmonics of the video components can be generated.

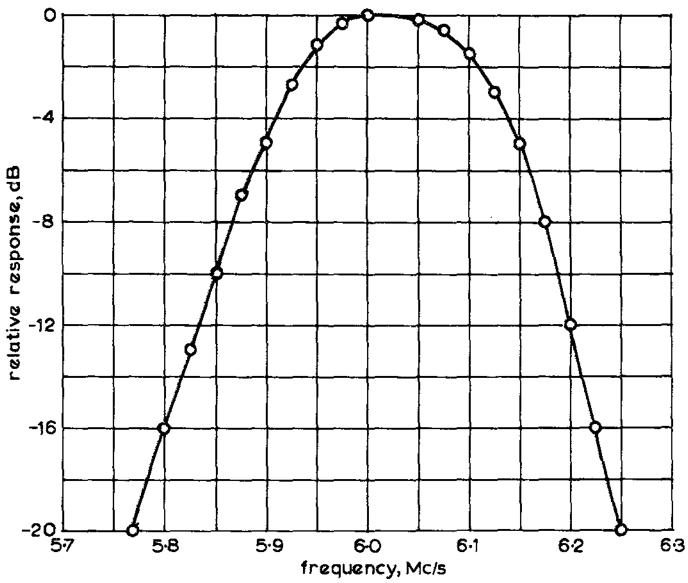

Fig. 3

Intercarrier sound channel response, receiver A

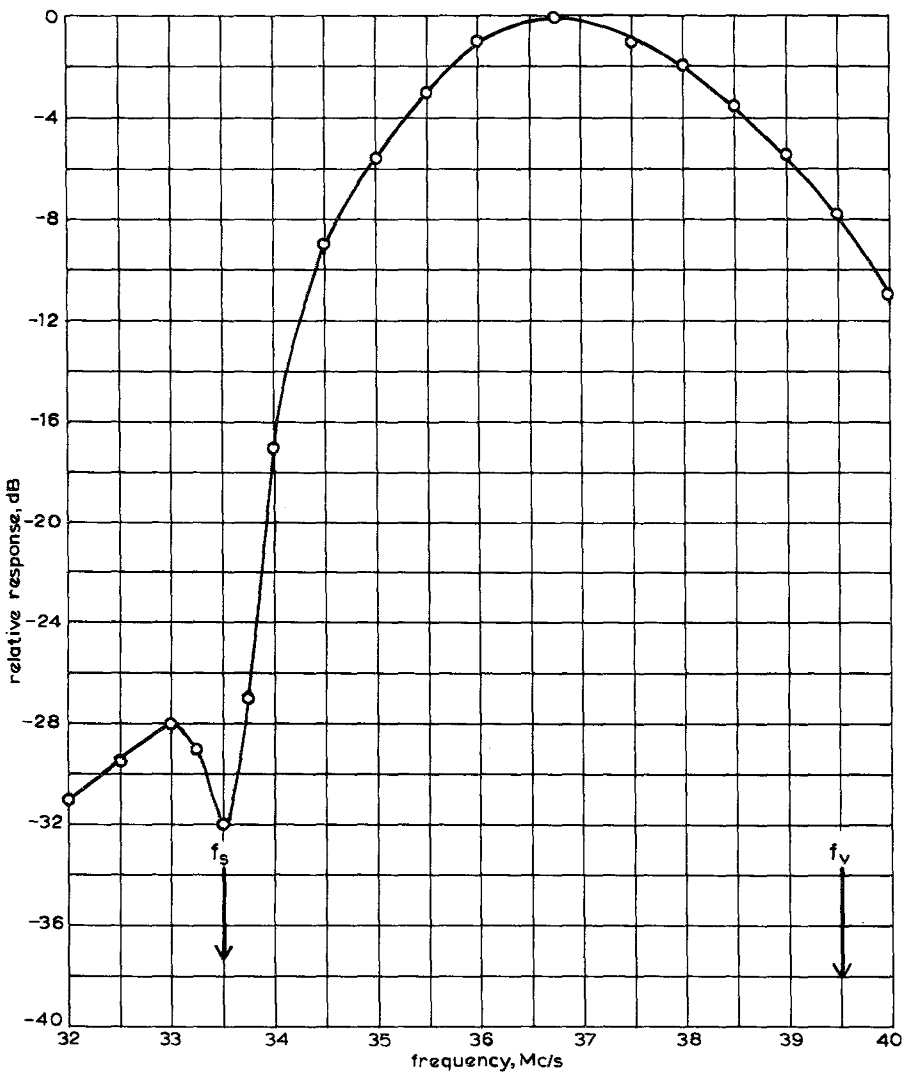

Fig. 4 - I.F. amplifier response, receiver B

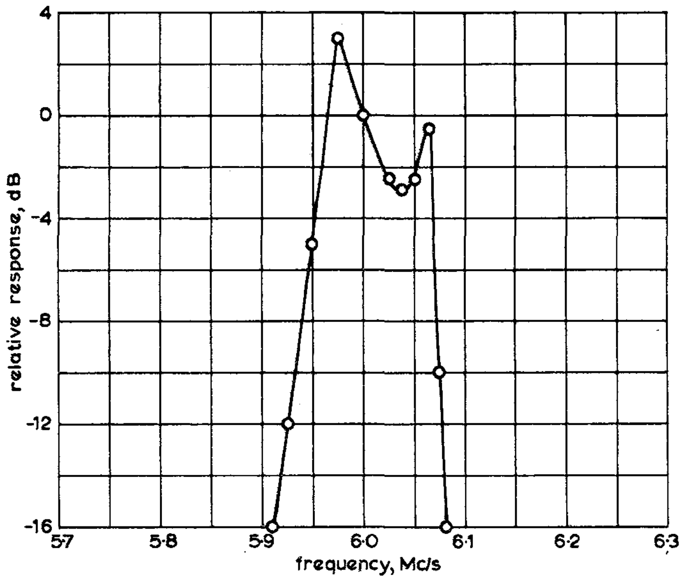

Fig. 5

Intercarrier sound channel response, receiver B

The a.m. suppression ratio of each receiver was measured by applying, in turn, two different input signals to the intercarrier sound amplifier. The first signal was frequency modulated at 1000 c/s with a peak deviation of ± 20 kc/s, the second was simultaneously amplitude modulated 40% at 1000 c/s and frequency modulated ± 20 kc/s at 100 c/s. The output produced from each input signal was measured through a 250 c/s high-pass filter. The ratio of the output due to f.m. alone at 1000 c/s to that due to simultaneous a.m. at 1000 c/s and f.m. at 100 c/s was:

Receiver A	:	34 dB
Receiver B	:	30 dB

4. DISCUSSION OF RESULTS

4.1. Quadrature Distortion

From Fig. 2 it can be seen that the i.f. response of receiver A is -7·5 dB at the vision carrier frequency and -39·5 dB at the sound carrier frequency, relative to the response at the 3 Mc/s sideband. Using Colebrook's analysis it can be shown that, with continuous full modulation at 3 Mc/s in the video channel, the 6 Mc/s second harmonic component produced by quadrature distortion alone will be some 12 dB greater in amplitude than the intercarrier sound signal. Such a condition of modulation is not likely to occur in practice, but one practical case which does occur, and which may not be unrepresentative of the type of fine detail which is transmitted, is the test card. Test Card C, which was in use at the time of the investigation during January and February 1964, included a resolution pattern with a nominal frequency of 3·1 Mc/s. If we assume for simplicity that this produces sinusoidal modulation from black level to peak white level and that the frequency is 3 Mc/s (this could in fact result from minor non-linearity of the scanning waveform) the second harmonic energy spectrum will be ± 160 kc/s wide at the -3 dB points. Fig. 3 shows the bandwidth of the intercarrier sound channel as ± 100 kc/s at the -3 dB points. On

the assumption that the peak value of the interfering pulse is reduced in the ratio 100/160, i.e. by 4 dB, the ratio of the peak interference to the peak intercarrier sound signal will be 8 dB and audible disturbance of the sound signal will be inevitable.

Considering receiver B in the same circumstances, Figs. 4 and 5 show that the sound notch is 8 dB 'shallower' than with receiver A while the intercarrier channel is approximately half the bandwidth of that in receiver A; the response at the 3 Mc/s sideband relative to that at the vision carrier is substantially the same in both receivers. The ratio of the peak interference to the peak intercarrier sound signal will thus be 14 dB more favourable with receiver B, that is -6 dB. In this case it is likely that no audible interference will result, since the frequency modulation detector will be operating above the 'improvement threshold', i.e. with the carrier level exceeding the peak interference level at the output of the last i.f. stage.

4.2. Non-Linear Distortion in the Video Amplifier

From Fig. 1 it is apparent that sound interference can also be produced in receiver A by distortion of signals in the video modulation having frequencies which are lower sub-multiples of 6 Mc/s; this effect would be expected to be more serious if the setting of the contrast control were advanced beyond the point used in the test, as mentioned in Section 3.

4.3. Listening Tests

Listening tests confirmed these conclusions. With receiver A, when accurately tuned to a transmission modulated with the original Test Card C and with normal contrast, sound interference was audible. This had a random impulsive character similar to that resulting from car ignition interference on a f.m. receiver. Increasing the picture contrast caused the sound interference level to increase and to lose its random character, becoming more of a 50 c/s buzz. Slight detuning in either direction reduced the level of the interference, as would be expected from the sharp minimum of response at the sound carrier frequency when correctly tuned (see Fig. 2). When receiving the modified Test Card C in which the resolution bar patterns had been changed, the bar pattern having a nominal 3·1 Mc/s frequency being deleted, there was no audible interference when operating with normal contrast. Advancing the contrast control made the interference re-appear and, as before, slight detuning reduced it.

Some listening tests were made on the films which formed the bulk of the trade test transmissions and it was found that with receiver A, sound interference occurred only when the picture contained areas of fine detail at high contrast. Two examples were a line drawing of architectural detail and a picture of a jacket with a well defined check pattern.

With receiver B it was not found possible to produce this form of interference with any reasonable condition of tuning or contrast on any type of picture.

A further observation was made on both receivers to determine the visibility of the sound-to-chrominance beat pattern when receiving colour transmissions. With receiver A this pattern was just discernible when viewed from a very short distance and would probably be below perceptibility under normal viewing conditions. With

receiver B the pattern was readily visible at close viewing distances. In both cases the receivers were accurately tuned to place the sound carrier in the sound notch; detuning made the pattern more visible.

5. CONCLUSIONS

With television receivers using the intercarrier sound technique, interference in the sound channel can be produced as a result of non-linear distortion of components in the video-frequency signal which have frequencies that are integral sub-multiples of 6 Mc/s. When the intercarrier sound signal is obtained directly from the output of the vision detector, only video-frequency components having frequencies close to 3 Mc/s are likely to produce sufficient harmonic energy within the pass-band of the intercarrier-frequency amplifier to give audible interference. When the intercarrier signal is obtained from the output of the video-frequency amplifier, non-linear distortion in this stage can be an additional source of sound interference. This may, in some receivers, produce 6 Mc/s components of significant amplitude from signals having frequencies which are lower sub-multiples of the intercarrier beat frequency.

There is no evidence that audible self-generated interference of this type is widespread at present. However, it does appear that the margin of safety in some existing receivers is very small and it is desirable that the limitations of the intercarrier technique as currently employed should be appreciated.

The possibility of this form of interference occurring can be minimized by

(a) Avoiding the use of amplifier stages common to both the video and intercarrier sound signals.

(b) Reducing the bandwidth of the intercarrier-frequency amplifier to the minimum necessary for the system.

(c) Ensuring adequate suppression of amplitude modulation in the intercarrier sound circuits by efficient amplitude limiting.

It would be possible to eliminate this effect completely by reducing the attenuation of the sound carrier in the i.f. amplifier. This, however, would be an undesirable expedient since, unless the attenuation of the sound carrier relative to the vision carrier is at least 30 dB, a visible sound-to-chrominance beat pattern will be produced when receiving colour transmissions. The use of a separate detector to obtain the intercarrier sound signal (at 6 Mc/s) would permit the attenuation of the sound carrier at the input to each detector to be adjusted so that the requirements for freedom from sound-to-chrominance beat patterns and from video-harmonic sound interference could both be satisfied. This technique is frequently employed in colour receivers.

An additional cause of sound buzz dependent on picture content is direct amplitude modulation of the intercarrier signal by audio-frequency components of the video waveform as a result of overloading occurring in some stage of the receiver. This has not been considered in this report but the measures referred to above under (a) and (c) would help to prevent audio interference from this cause also.

6. ACKNOWLEDGEMENTS

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